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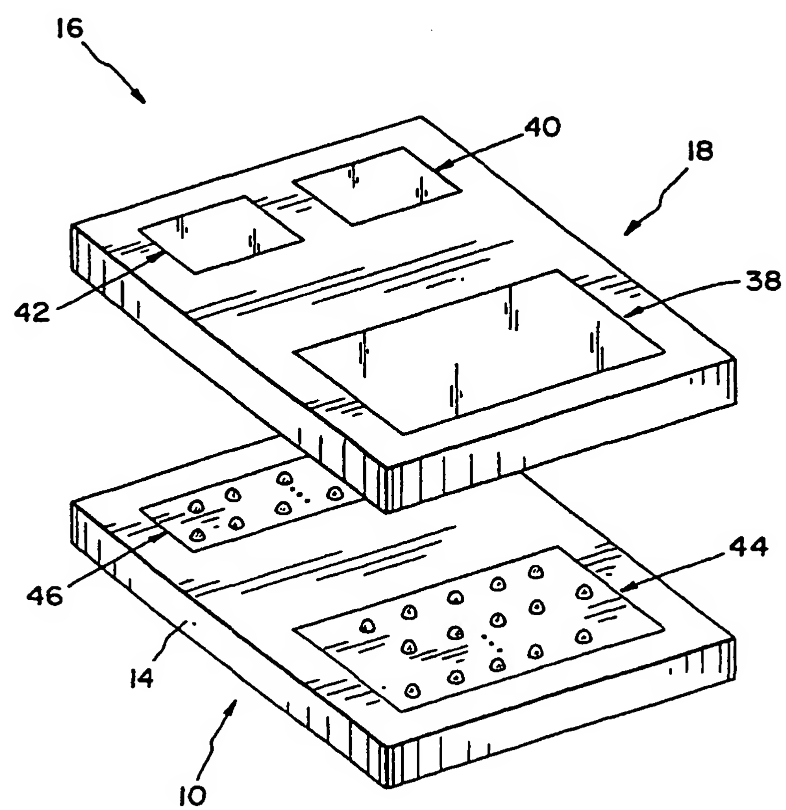
(54) Title: LED BACKLIGHTING APPARATUS FOR USE IN FUEL DISPENSERS

(57) Abstract

A lighting assembly (10) for use in backlighting a liquid crystal display (18) integral with a fuel dispensing system includes a plurality of light emitting diodes disposed on a circuit board and arranged into a matrix configuration having a plurality of rows each including a respective LED arrangement. The LED arrangement for each row of the matrix is staggered relative to the LED arrangements for any adjacent rows of the matrix. The staggering enables the light emanations from each respective one of the LED's to overlap with the light emanations from at least one other LED, resulting in a composite light pattern incident on the backlighting surface of the LCD that is characterized by a substantial absence of non-lit areas.



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LED BACKLIGHTING APPARATUS FOR USE IN FUEL DISPENSERS

BACKGROUND OF THE INVENTION

1. Field of the invention.

The present invention relates generally to an apparatus for backlighting an LCD-type display and, more particularly, to a lighting assembly utilizing an array of staggered light emitting diodes to illuminate the liquid crystal display, which preferably forms part of a display assembly integrated within a fuel dispenser system.

2. Description of the related art.

Viewing apparatus of the type employing liquid crystal displays (LCDs) require some form of background illumination so that an observer can legibly read the activated alphanumeric characters on the display when there is little or no ambient light present. Efforts aimed at providing such background illumination have developed lighting apparatus that generates a suitable light beam and then accurately directs it onto the LCD backsurface. One area of concern involves preventing concentrated areas of light known as "hot spots" from appearing in the background of the liquid crystal display. Their appearance, which is readily discernible by the human eye, degrades the quality and effectiveness of the

background illumination that is being provided by the lighting apparatus.

Previous implementations of the background lighting apparatus have employed cold cathode-type devices to illuminate the LCD. Other conventional arrangements have used light-emitting diodes (LEDs) to generate the light energy that is subsequently transmitted to the LCD. These arrangements typically address the hot-spot problem by utilizing LED-LCD configurations that avoid any direct projection of the LED light pattern onto the aft surface of the LCD. For example, a reflector structure may be interposed between the LED arrangement and display assembly in order to redirect the LED emissions onto the LCD backsurface. For this purpose, the reflector structure is typically treated with a coating material that serves to attenuate the undesirable concentration of light that is characteristic of hot-spot areas. Although indirect projection of the LED image onto the LCD may provide some degree of hot-spot reduction, this improvement comes at the expense of increased cost and component count due to the addition of a reflector structure. Moreover, incorporating such a reflectivity feature imposes strict tolerances on the orientation and spatial relationship of the devices in view of the fact that imprecise alignment between the various devices may inhibit proper illumination of the fixed backlighting area for the LCD..

Another problem that arises in such backlighting apparatus involves the non-uniformity of the LED illumination pattern with respect to both intensity and extent of coverage. For example, the light patterns generated by conventional LED backlighting arrangements are typically characterized by areas of insufficient illumination and even dark spots completely devoid of any light. This interleaving of the illumination pattern with such non-lit and poorly lit areas produces a substandard backlighting operation that is unacceptable for most commercial applications that rely upon display units having LED backlighting apparatus as the principal customer interface device.

SUMMARY OF THE INVENTION

According to the present invention there is provided a lighting assembly for backlighting a liquid crystal display (LCD) assembly. The lighting assembly includes a plurality of light emitting diodes disposed on a circuit board in an array configuration. The array configuration is preferably defined by a plurality of rows each comprising respective ones of the LEDs, wherein each row of LEDs is preferably staggered with respect to any adjacent LED rows. This staggering is preferably provided in a manner sufficient to enable the light emanations from each respective one of the LEDs to overlap with the light emanations from at least one other LED. This overlapping enables the collective light emanations from the

plurality of LEDs to illuminate the backlighting surface of the LCD with a composite light pattern characterized by a substantial absence of non-lit areas. Additionally, the LED array is preferably configured relative to the LCD such that the LED emissions propagate directly to the backlighting surface of the LCD. The lighting assembly is particularly useful as part of a display unit associated with a fuel dispensing system.

The invention, in one form thereof, comprises a lighting assembly for use in operatively backlighting a display assembly. The lighting assembly comprises a circuit board and a plurality of light sources disposed on the circuit board in an array configuration, such plurality of light sources being operative to illuminate a backlighting surface of the display assembly. The array configuration for the plurality of light sources is characterized by having at least one light source arrangement comprising ones of the plurality of light sources being disposed in an offset manner relative to at least one other light source arrangement comprising other ones of the plurality of light sources.

The array configuration for the plurality of light sources is defined, in one form thereof, by a plurality of rows of light source arrangements each comprising respective ones of the plurality of light sources, wherein each respective one of the plurality of rows of light source

arrangements is offset from any other ones of the plurality of rows of light source arrangements adjacent therewith. The offset between each respective one of the plurality of rows of light source arrangements and any other ones of the plurality of rows of light source arrangements adjacent therewith is sufficient to enable the light emanations from each respective one of the plurality of light sources to overlap with the light emanations from at least one other one of the plurality of light sources. The light emanations from the plurality of light sources, in one form thereof, are effective in illuminating the backlighting surface of the display assembly with a light pattern characterized by a substantial absence of non-lit areas.

The plurality of light sources as disposed on the circuit board are preferably arranged relative to the display assembly such that light emanating from the plurality of light sources propagates directly to the backlighting surface of the display assembly. The plurality of light sources, in one form thereof, further comprises a plurality of light emitting diodes. A means is optionally provided for diffusing the light emanations from the plurality of light sources and for directly providing the diffused light emanations to the display assembly at the backlighting surface thereof. The display assembly, in one form thereof, further comprises a liquid crystal display.

The invention, in another form thereof, comprises a lighting assembly for use in operatively backlighting a display assembly. The lighting assembly comprises, in combination, a circuit board and a plurality of light sources disposed on the circuit board, wherein such plurality of light sources are operative to generate a light pattern illuminating a backlighting surface of the display assembly, and wherein the plurality of light sources are arranged such that the generated light pattern incident on the backlighting surface of the display assembly is characterized by a substantial absence of non-lit areas.

The plurality of light sources are arranged, in one form thereof, into a plurality of rows each comprising respective ones of the plurality of light sources, wherein each respective one of the plurality of rows of light sources is staggered relative to any other ones of the plurality of rows of light sources adjacent therewith. The staggered relationship between each respective one of the plurality of rows of light sources and any adjacent ones of the plurality of rows of light sources is preferably sufficient to enable the light emanations from each respective one of the plurality of light sources to overlap with the light emanations from at least one other one of the plurality of light sources.

The invention, in another form thereof, is directed to a lighting assembly for use in operatively backlighting a

display assembly, comprising a circuit board and a plurality of light sources disposed on the circuit board, wherein the plurality of light sources are operative to illuminate a backlighting surface of the display assembly, and wherein the plurality of light sources are arranged such that the light emanations from at least one of the plurality of light sources overlap with the light emanations from at least one other one of the plurality of light sources.

The plurality of light sources are arranged, in one form thereof, into a plurality of rows each comprising respective ones of the plurality of light sources, wherein at least one of the plurality of rows of light sources is staggered relative to any other ones of the plurality of rows of light sources adjacent therewith. In a preferred form, each respective one of the plurality of rows of light sources is staggered relative to any other ones of the plurality of rows of light sources adjacent therewith. The staggered relationship between at least one of the plurality of rows of light sources and any other ones of the plurality of rows of light sources adjacent therewith is sufficient such that the light pattern generated by the plurality of light sources incident on the backlighting surface of the display assembly is characterized by a substantial absence of non-lit areas. The light emanations from each respective one of the plurality

of light sources preferably overlap with the light emanations from at least one other one of the plurality of light sources.

The invention, in another form thereof, is directed to a fuel dispensing system comprising, in combination, a fuel dispensing assembly arranged to operatively provide fuel in association with a vehicle refueling operation; and a display assembly arranged to operatively display information relating to the vehicle refueling operation; wherein the display assembly comprises a liquid crystal display, a circuit board, and a plurality of light sources disposed on the circuit board in an array configuration, wherein the plurality of light sources are operative to illuminate a backlighting surface of the liquid crystal display, and wherein the array configuration for the plurality of light sources is characterized by having at least one light source arrangement comprising ones of the plurality of light sources being disposed in an offset manner relative to at least one other light source arrangement comprising other ones of the plurality of light sources.

The array configuration for the plurality of light sources is defined, in one form thereof, by a plurality of rows each comprising respective ones of the plurality of light sources, wherein each respective one of the plurality of rows of light sources is offset from any other ones of the plurality of rows of light sources adjacent therewith. The

offset between each respective one of the plurality of rows of light sources and any other ones of the plurality of rows of light sources adjacent therewith is preferably sufficient to enable the light emanations from each respective one of the plurality of light sources to overlap with the light emanations from at least one other one of the plurality of light sources. The light emanations from the plurality of light sources, in one form thereof, are effective in illuminating the backlighting surface of the liquid crystal display with a light pattern characterized by a substantial absence of non-lit areas.

The plurality of light sources as disposed on the circuit board are preferably arranged relative to the liquid crystal display such that light emanating from the plurality of light sources propagates directly to the backlighting surface of the liquid crystal display. The plurality of light sources, in one form thereof, further comprises a plurality of light emitting diodes.

One advantage of the present invention is that the lighting assembly effectively generates a substantially uniform light pattern incident on the LCD backlighting surface that is characterized by the absence of light spots (i.e., minimally lit areas) and non-lit areas.

Another advantage of the present invention is that the light pattern may be selectively formed through appropriate

staggering and spacing of the LEDs to permit the development of a more uniform illumination of the LCD backsurface relative to conventional arrangements.

Another advantage of the present invention is that the LED emanations can be projected directly onto the LCD assembly, thereby avoiding the use of reflector structures found in conventional systems.

Another advantage of the present invention is that the lighting assembly may be implemented with fewer LEDs to achieve the same illumination as conventional arrangements by optimally constructing the LED matrix through appropriate selection of various design parameters such as the particular form of staggering between the individual rows of LEDs, the radius and angle of emitted light, the spatial separation between the LED matrix and the LCD backlighting surface, and the spatial separation between individual LEDs and between rows of LEDs.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention will be better understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is an upper elevational perspective view of a lighting assembly in accordance with one embodiment of the present invention;

Fig. 2 is an upper plan view of the light pattern generated by one representative grouping of LEDs from the lighting assembly shown in Fig. 1 to illustrate the manner of overlap between the emissions of various LEDs, according to one aspect of the present invention;

Fig. 3 is an upper plan view of the light pattern generated by one representative grouping of LEDs from the lighting assembly shown in Fig. 1 to illustrate a condition of minimum interference between the emissions of various LEDs, according to another aspect of the present invention;

Fig. 4 is a side elevational view illustrating the emissions from two representative LEDs within the same row of the LED array for the lighting assembly of Fig. 1;

Fig. 5 is a schematic view of one representative arrangement of LEDs from the LED array shown in Fig. 1 to illustrate the separation needed between the light-emitting diodes to effectuate a 360 degree circular output light pattern;

Fig. 6A is an upper plan view of the light pattern generated by a representative grouping of LEDs from the arrangement shown in Fig. 3 to illustrate the design criteria

for the LED matrix that would enable the development of such a light pattern;

Fig. 6B is an upper plan view of the light pattern generated by a representative grouping of LEDs from another form of LED arrangement for the lighting assembly of Fig. 1 associated with a condition of maximum interference according to another aspect of the present invention, illustrating the design criteria for the LED matrix that would enable the development of such a light pattern;

Fig. 7 is an upper elevational perspective view of a liquid crystal display assembly illustrating the manner of backlighting an LCD with the lighting assembly of Fig. 1; and

Fig. 8 is a block diagram illustration of a fuel dispensing system that incorporates the lighting assembly of Fig. 1 in accordance with another embodiment of the present invention.

Corresponding reference characters indicate corresponding parts throughout the several views. The exemplification set out herein illustrates one preferred embodiment of the invention, in one form, and such exemplification is not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings, and particularly to Figs. 1-2, there is shown in Fig. 1 an upper perspective view of a

lighting assembly 10 including a plurality of light sources shown collectively at 12 arranged on a circuit board 14 for use in illuminating the backlighting surface of a display assembly such as a liquid crystal display, according to one embodiment of the present invention. Fig. 2 is an upper plan view of the light pattern generated by one representative grouping of light sources from lighting assembly 10 to illustrate the manner of overlap between the emissions of various neighboring light sources, according to one aspect of the present invention. As discussed below in further detail, the illustrated plurality of light sources 12 is preferably provided in an array or matrix configuration in which adjacent rows of light sources are staggered or offset relative to one another. The illustrated light pattern of Fig. 2 represents one form of such staggering and accompanying spatial separation between individual LEDs and between rows of LEDs to facilitate the indicated overlapping between the light emanations generated by various ones of the light sources. These light sources 12 are preferably provided in the form of light-emitting diodes (LEDs). Referring briefly to Fig. 7, the illustrated lighting assembly 10 of Fig. 1 preferably forms part of a display system 16 for illuminating the backlighting surface of a liquid crystal display assembly 18, as will be discussed further in more detail.

Referring to Fig. 1, the illustrated plurality of light sources 12 disposed on circuit board 14 are arranged into an array or matrix configuration (hereinafter "LED array") defined in one illustrative form thereof by a plurality of discrete rows each comprising a respective arrangement of light-emitting diodes. The manner of organizing LED array 12 is preferably chosen such that each row of LEDs is staggered or offset with respect to any other rows of LEDs adjacent therewith. For example, the illustrated LED arrangement for row 2 is staggered relative to the LED arrangements of adjacent rows 1 and 3. In a preferred form, the individual LED rows are staggered in equivalent alternating fashion. The illustrated matrix configuration is shown for illustrative purposes only and should not be considered in limitation of the present invention as it should be apparent that other such array-type arrangements are possible within the scope of the present invention. Moreover, the indicated number of light-emitting diodes is shown for illustrative purposes only and may include any number of such light sources.

As disclosed herein, the use of an array or matrix to define the organization of the plurality of light-emitting diodes 12 should be understood as encompassing any ordered or random arrangement or placement of the LEDs on circuit board 14 in a manner suited to the development of a desired light emissions pattern for illuminating the target structure, e.g.,

the backlighting surface of a liquid crystal display. Selecting the particular LED arrangement may take into account such factors as determining the appropriate interrelationship and/or interaction between the emanations of various ones of the LEDs in order to generate a desired illumination pattern. For this purpose, LED array 12 preferably takes the form shown in Fig. 1 in which the individual rows of LEDs are staggered and spaced-apart relative to one another in a manner sufficient to create a desired overlap between various ones of the LEDs, such as shown in Fig. 2. Alternatively, the staggering relationship and the spacing between individual LEDs and between the discrete rows may be selected to create different illumination patterns, such as shown in the illustrative views of Fig. 3 and Figs. 6A-B depicting other LED arrangements.

It should be apparent that the staggering relationship depicted by Fig. 1 is provided for illustrative purposes only and should not be considered in limitation of the present invention since other forms of staggering are possible within the scope of the present invention depending upon the type of light pattern desired for generation by LED array 12. For example, as will be discussed below in connection with Fig. 2, the staggering relationship is selected with a view towards generating a composite light pattern characterized by a substantial absence of non-lit areas, namely by developing an

overlap between the light emissions of each LED and the light emissions of each nearest-neighbor LED located within the same row and within any immediately adjacent rows. This illumination pattern provides a more uniformly distributed light intensity across its coverage area relative to conventional light patterns that include areas of inadequate lighting and dark spots commingled with areas of illumination. Although the type of staggering depicted in the drawings takes the form of providing an offset between the individual rows of LED arrangements, this depiction is for illustrative purposes only since the use of staggering or offsetting as disclosed herein should be understood as encompassing any type of spaced-apart relation between any ones of the LEDs, not necessarily limited to staggering on a row-to-row basis. For example, while each row of LEDs may be staggered relative to other rows, the arrangement of LEDs within the same row may be segregated into various subgroups having a staggering relationship therebetween.

As used herein, "circuit board" should be understood as encompassing any structure or formation that accommodates the placement of LED array 12 and that includes, but is not limited to, a substrate, a generally planar structure that integrally receives the LEDs, a platform dedicated to holding the LEDs, and an integrated circuit board that includes other components in addition to LED array 12. Moreover, the circuit

board may include LED array 12 alone or in combination with other devices, such as in an IC configuration. The wiring and power source for the LEDs may be located on-board or provided by any other means known to those skilled in the art.

As used herein, "light source" should be understood as encompassing any device, component, or other such structure capable of emitting electromagnetic energy, preferably in a form suitable to provide backlighting illumination. Accordingly, the light energy preferably falls within the visible spectrum, although other spectral regions may be utilized suited to the particular application. The light source includes, but is not limited to, light-emitting diodes. The individual LEDs may be of any suitable type such as T1 or surface mount.

Referring now to Fig. 2, there is shown an upper plan view of the light pattern generated by a representative grouping of LEDs from rows 1-3 of LED array 12 of Fig. 1 staggered in accordance with one aspect of the present invention to provide an overlapping illumination pattern. The LEDs are arranged in such a manner that the light emissions from each respective one of the light-emitting diodes overlaps with the light emissions from various other light-emitting diodes in LED array 12. In particular, the light emanating from representative LED 20 of row 2 overlaps with the light emanating from the LEDs immediately adjacent therewith in the

same row (i.e., LEDs 34 and 36) and overlaps with the light emanating from the nearest-neighbor LEDs from the adjacent rows, i.e., LEDs 22 and 24. in row 1 and LEDs 26 and 28 in row 2. This form of overlapping, when carried out for the entire LED array 12, has the effect of developing a composite light pattern incident on the backlighting surface of the display assembly (e.g., liquid crystal display) that is characterized by a substantial absence of non-lit areas. The net result of such overlapping is the creation of a more uniform light pattern as compared to conventionally-generated light patterns featuring multiple dark spots (i.e., non-lit areas) and light spots (i.e., areas of minimal illumination). The overlapping effectively cancels out any such light spots and non-lit areas that are otherwise present in the light emanations generated by conventional lighting arrangements.

Referring to Fig. 3, there is shown a light pattern generated by a representative grouping of LEDs according to one alternative arrangement of LED array 12 that is characterized by minimum interference between the light emanations of each LED and the light emanations from same-row adjacent LEDs and adjacent-row nearest-neighbor LEDs. This illumination pattern contrasts with Fig. 2 in which the emanations from each LED overlap with the same-row adjacent LEDs and adjacent-row nearest-neighbor LEDs. This particular light pattern exhibits a lack of hot-spots due to the

substantial absence of overlapping between the emissions of the individual LEDs. As applied to the entire LED array 12, the LED arrangement depicted representatively in Fig. 3 results in each LED being able to generate a substantially 360 degree circular output illumination pattern. A further examination of this arrangement is disclosed in connection with Fig. 6A.

Referring to Fig. 4, there is shown for purposes of analysis a side-elevational diagrammatic view of the illustrative light emissions from two adjacent LEDs 30 and 32 positioned in the same row of LED array 12. This diagram shows in particular the inter-relationship between the design parameters "phi" (angle of light emission from the LED, i.e., viewing angle); "h" (the separation height between LED array 12 and the backlighting surface being illuminated); and "w" (the distance between LEDs in the same row). By using conventional trigonometric analysis known to those skilled in the art, the following expression can be obtained: tangent ("alpha") = (w/2)/h. With the bisected angle "alpha" equaling "phi"/2, this equation can be further solved to yield the following relationship: w=2h*tan("phi"/2).

Referring to Fig. 5, there is shown for purposes of analysis an upper diagrammatic view of an arrangement of row-staggered LEDs to illustrate the spatial separation "D" needed between adjacent rows to ensure a 360 degree circular output

pattern for each individual LED. This output pattern, for example, is illustratively exhibited by the LED arrangement shown in Fig. 3. One condition for such fully-circular output pattern is that each respective LED is separated from each of its same-row adjacent LEDs and each of its adjacent-row nearest-neighbor LEDs by at least the distance "w" referenced in connection with Fig. 4. For example, representative LED 20 is separated from same-row LEDs 34 and 36 by distance "w" and is separated by distance "w" from each of its nearest-neighbor LEDs 22, 24 and LEDs 26, 28 in the adjacent rows. By using conventional trigonometric analysis known to those skilled in the art, the following expression can be obtained: $D = (w^2 - w^2/4)^{(1/2)}$.

Referring to Figs. 6A and 6B, there is shown for purposes of analysis a pair of upper diagrammatic views of representative light patterns associated respectively with a condition of minimum interference and a condition of maximum interference for the light pattern incident on the LCD backlighting surface. These views facilitate a determination of the values for spatial separation between same-row adjacent LEDs and the spatial separation between adjacent rows that produce the aforementioned interference conditions. These views each depict for the illustrated LED arrangement the illumination pattern at the height "h" above the LEDs referenced in connection with Fig. 4.

Referring first to Fig. 6A, the use of conventional trigonometric analysis known to those skilled in the art leads to the following expressions for "w" (the separation distance between LEDs within the same row) and "D" (the separation distance between adjacent LED rows): $w = 2r$ and $D = (w^2 - w^2/4)^{(1/2)}$, which is the same expression found in connection with Fig. 5. Referring now to Fig. 6B, the use of conventional trigonometric analysis known to those skilled in the art leads to the following expressions for w' (the separation distance between LEDs within the same row) and D' (the separation distance between adjacent LED rows): w' = 2r*cos(30 degrees) and D' = [r + r*sin(30 degrees)], wherein "r" represents the radius of the circular output pattern at height h above LED array 12.

Referring now to Fig. 7, there is shown an upper perspective view of display system 16 including a lighting assembly 10 suitably arranged to provide backlighting illumination of liquid crystal display (LCD) assembly 18 in accordance with another embodiment of the present invention. The illustrated LCD assembly 18 includes, in one illustrative form thereof, a graphics display LCD 38, a 7-segment LCD 40, and another display structure 42, all preferably of conventional construction. For illuminating this arrangement of LCD structures, lighting assembly 10 is provided in the illustrated form including a first LED array 44 to illuminate

graphics display LCD 38 and a second LED array 46 to illuminate 7-segment LCD 40 and display structure 42. The illustrated first and second LED arrays 42 and 44 each include a respective plurality of discrete LEDs disposed on circuit board 14 and constructed in accordance with the principles of the present invention described above for LED array 12 in connection with Figs. 1-6 to facilitate proper illumination of the designated LCD structures.

The indicated arrangement for LCD assembly 18 is provided for illustrative purposes only as it should be apparent to those skilled in the art that LCD assembly 18 may be provided in various other forms capable of being illuminated at a backlighting surface thereof with the appropriate configuration of lighting assembly 10, namely by selecting the proper LED array configuration. Additionally, LCD assembly 18 may be provided in the integral form shown in Fig. 7 or as an arrangement of discrete LCD panel assemblies.

In operation, the illustrated first LED array 44 and second LED array 46 are each activated in a conventional manner to generate respective light emanation patterns that propagate towards and become incident upon the backlighting surface of LCD assembly 18, namely at the respective undersides of graphics display LCD 38, 7-segment LCD 40, and display structure 42. The LEDs of first and second LED arrays 42 and 44 may be controllably and selectively activated via a

programmable controller (not shown) provided in the form of a dedicated hardwired connection or microprocessor arranged for connection to the LEDs by conventional means. Other alternative means known to those skilled in the art may also be used to activate the first and second LED arrays 42 and 44.

In accordance with another aspect of the present invention featured in Fig. 7, lighting assembly 10 is suitably disposed at a location and orientation relative to LCD assembly 18 such that the backlighting operation takes place via direct transmission of the light emissions from lighting assembly 10 to the undersurface of LCD assembly 18. This direct propagation of light emissions distinguishes from other arrangements in which an intermediately-positioned reflector structure redirects the light emissions to effect an indirect projection of light onto the LCD backsurface. As disclosed herein, the terms "direct propagation" and "direct transmission" are used interchangeably and should be understood, along with other equivalent expressions, as encompassing the communication of light between lighting assembly 10 and the backlighting surface of LCD assembly 18 over a substantially non-reflective propagation path. For this purpose, first and second LED arrays 42 and 44 preferably define a generally planar device configuration that lies in spaced-apart relation generally parallel to and rearwardly of the backlighting surfaces associated with LCD assembly 18,

such that LED arrays 42 and 44 when operational are producing emissions in direct light-illuminating registration with their respective backlighting surfaces of LCD assembly 18. It should be understood, however, that the present invention may be provided in other alternative forms that include a reflector structure suitably interposed between lighting assembly 10 and LCD assembly 18 for redirecting the LED-generated light emanations onto the LCD backlighting surface. Incorporating such a reflector structure does not interfere with or limit the functionality or efficacy of any other aspects of the present invention, specifically the development of a desired illumination pattern as described previously by utilizing the appropriate staggering and spacing of LEDs to create a suitable overlapping of light emissions that prevents the appearance of lightspots and non-lit areas, for example.

Referring now to Fig. 8, there is shown in block diagram format a fuel dispensing system 50 including a fuel dispensing apparatus 52 connected to an interactive display module 54 incorporating lighting assembly 10 of Figs. 1-7, according to another embodiment of the present invention. Fuel dispensing apparatus 52 is of conventional construction and functions generally to operatively provide fuel in connection with a vehicle refueling operation. Display module 54 includes a fuel station liquid crystal display 56 of the type similar to LCD assembly 18 of Fig. 7, which is backlit by lighting

assembly 10 in the manner described previously with reference to Figs. 1-7. A user-accessible and user-activatable touchscreen 58 is provided to enable the refueling operator to make various requests and issue other commands to fuel dispensing apparatus 52 through controller 60. These instructions and commands are made in furtherance of the refueling operation. The signals supplied by touchscreen 58 are provided to lighting assembly 10 in a suitable format to enable selective activation of the associated LED arrays such that the user-provided commands, responses from the fuel station controller, and/or other relevant information are displayed for the operator at fuel station LCD 56. Touchscreen 58 may therefore be implemented by other means that operate to controllably activate the LED elements and thereby generate the desired backlighting of LCD 56. The specific form and manner of integrating lighting assembly 10 into fuel dispensing system 50 is not limited to the implementation shown in Fig. 8 but should be understood as encompassing other suitable arrangements in addition to other types of fuel delivery systems. Additionally, although lighting assembly 10 of the present invention is integrated within a fuel delivery system according to a preferred implementation thereof, the invention is not so limited in its application but may be extended to other uses that require illumination of a surface.

Optional features may be included such as providing edge-lighting to complement the array-type LED organization illustrated by Figs. 1-7, in which the LED array is disposed at least in part within an interior space of circuit board 14. Additionally, a semi-opaque diffuser structure may be interposed between lighting assembly 10 and LCD assembly 18 to diffuse the LED emissions and then provide the diffused light to the backsurface of LCD assembly 18. The diffusion activity is consistent with the direct propagation of light from the LED arrays to the LCD backlighting surface.

The strategy adopted by the present invention for illuminating the backlighting surface of a display structure (e.g., liquid crystal display) involves providing a plurality of light-emitting diodes as the light source generation means and arranging the plural LEDs in a manner suitable for developing a desired light pattern incident on the backlighting surface. For example, by arranging the plural LEDs in an array configuration having a staggered relationship between LEDs (e.g., adjacent rows are offset relative to one another) and appropriately selecting the separation distance between LEDs in the same row and the separation distance between adjacent rows of LEDs, a desired illumination pattern produced by the LED array may be developed. This illumination pattern, for example, may be suitably formed to exhibit overlapping between the light emissions of various LEDs to

create a composite light pattern characterized by the substantial absence of dark spots and minimally lit areas, which by comparison appear in conventional illumination patterns. This overlapping facilitates the creation of a more uniform and evenly distributed backside illumination relative to conventional light patterns distinguished by an interleaving of non-lit and low-light areas with regions of sufficient illumination.

The various factors that may be taken into consideration to determine the particular form of the LED arrangement include, but are not limited to, the type of LED in use, the angle and radius of emitted light from each LED, the spatial separation between the LED array and LCD panel, the desired extent and degree of overlapping (or non-interference) among the various LED emissions, the spatial separation between the individual LEDs, the spatial separation between the individual array groups (e.g., LED rows), the desired density (which depends upon radius and angle of emitted light), and desired brightness (which depends upon density and intensity of the LEDs). Clearly some of these factors will influence the choice of other parameters. Manipulating these variables to arrive at a certain staggering relationship, for example, may permit the manufacturer to actually decrease the required number of LEDs without compromising the amount of illumination being provided. For example, the staggering can be designed

to produce a certain light output requiring fewer LEDs as compared to a non-staggered arrangement providing the same energy output.. This advantage would be attributable to the light interference properties that accompany the overlapping of the LED light emission patterns.

While this invention has been described as having a preferred design, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.

WHAT IS CLAIMED IS:

1. A lighting assembly for use in operatively backlighting a display assembly, said lighting assembly comprising:

a circuit board; and

a plurality of light sources disposed on said circuit board in an array configuration, said plurality of light sources being operative to illuminate a backlighting surface of said display assembly;

said array configuration for said plurality of light sources being characterized by having at least one light source arrangement comprising ones of said plurality of light sources being disposed in an offset manner relative to at least one other light source arrangement comprising other ones of said plurality of light sources.

2. The lighting assembly as recited in Claim 1, wherein the light emanations from at least one of said plurality of light sources overlap with the light emanations from at least one other one of said plurality of light sources.

3. The lighting assembly as recited in Claim 2, wherein the offset between said at least one light source arrangement and said at least one other light source arrangement being sufficient to effectuate at least in part the overlap of the light emanations from said at least one of said plurality of

light sources with the light emanations from said at least one other one of said plurality of light sources.

4. The lighting assembly as recited in Claim 3, wherein the array configuration for said plurality of light sources being defined by a plurality of rows of light source arrangements each comprising respective ones of said plurality of light sources, wherein each respective one of said plurality of rows of light source arrangements being offset from any other ones of said plurality of rows of light source arrangements adjacent therewith.

5. The lighting assembly as recited in Claim 4, wherein the offset between each respective one of said plurality of rows of light source arrangements and any other ones of said plurality of rows of light source arrangements adjacent therewith being sufficient to enable the light emanations from each respective one of said plurality of light sources to overlap with the light emanations from at least one other one of said plurality of light sources.

6. The lighting assembly as recited in Claim 5, wherein the light emanations from said plurality of light sources being effective in illuminating the backlighting surface of said display assembly with a light pattern characterized by a substantial absence of non-lit areas.

7. The lighting assembly as recited in Claim 4, wherein said plurality of light sources as disposed on said circuit

board being arranged relative to said display assembly such that light emanating from said plurality of light sources propagates directly to the backlighting surface of said display assembly.

8. The lighting assembly as recited in Claim 7, further comprises:

means for diffusing the light emanations from said plurality of light sources and for directly providing the diffused light emanations to said display assembly at the backlighting surface thereof.

9. The lighting assembly as recited in Claim 1, wherein the array configuration for said plurality of light sources being defined by a plurality of rows of light source arrangements each comprising respective ones of said plurality of light sources, wherein each respective one of said plurality of rows of light source arrangements being offset from any other ones of said plurality of rows of light source arrangements adjacent therewith.

10. The lighting assembly as recited in Claim 1, wherein the offset between said at least one light source arrangement and said at least one other light source arrangement being sufficient to enable the light emanations therefrom to illuminate the backlighting surface of said display assembly with a light pattern characterized by a substantial absence of non-lit areas.

AMENDED CLAIMS

[received by the International Bureau on 18 July 2000 (18.07.00)
original claims 1 and 3 amended; remaining claims unchanged (2 pages)]

1. A lighting assembly for use in operatively backlighting a display assembly, said lighting assembly comprising:

a circuit board;

a plurality of light sources disposed on said circuit board in an array configuration, said plurality of light sources being operative to illuminate a backlighting surface of said display assembly;

said array configuration for said plurality of light sources being characterized by having at least one light source arrangement comprising ones of said plurality of light sources being disposed in an offset manner relative to at least one other light source arrangement comprising other ones of said plurality of light sources; and

wherein the light emanations from at least one of said plurality of light sources overlap with the light emanations from at least one other one of said plurality of light sources.

2. The lighting assembly as recited in Claim 1, wherein the light emanations from at least one of said plurality of light sources overlap with the light emanations from at least one other one of said plurality of light sources.

3. The lighting assembly as recited in Claim 1, wherein the offset between said at least one light source arrangement

and said at least one other light source arrangement being sufficient to effectuate at least in part the overlap of the light emanations from said at least one of said plurality of

STATEMENT UNDER ARTICLE 19(1)

The differences between the specification pages 13 and 22 as filed and the specification pages 13 and 22 as amended is that various reference numbers are corrected and terminology standardized for the application.

The differences between the claims as filed and the claims as amended is that dependent Claim 3 is now incorporated into the base invention, Claim 1.

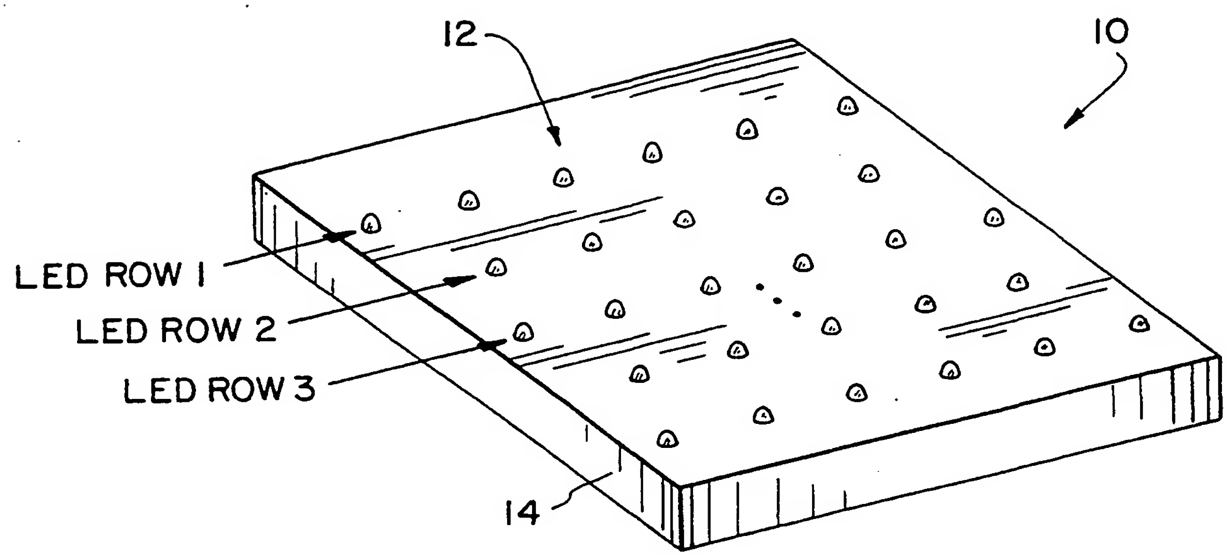

12
10
LED ROW 1
LED ROW 2
LED ROW 3
14

Fig. 1

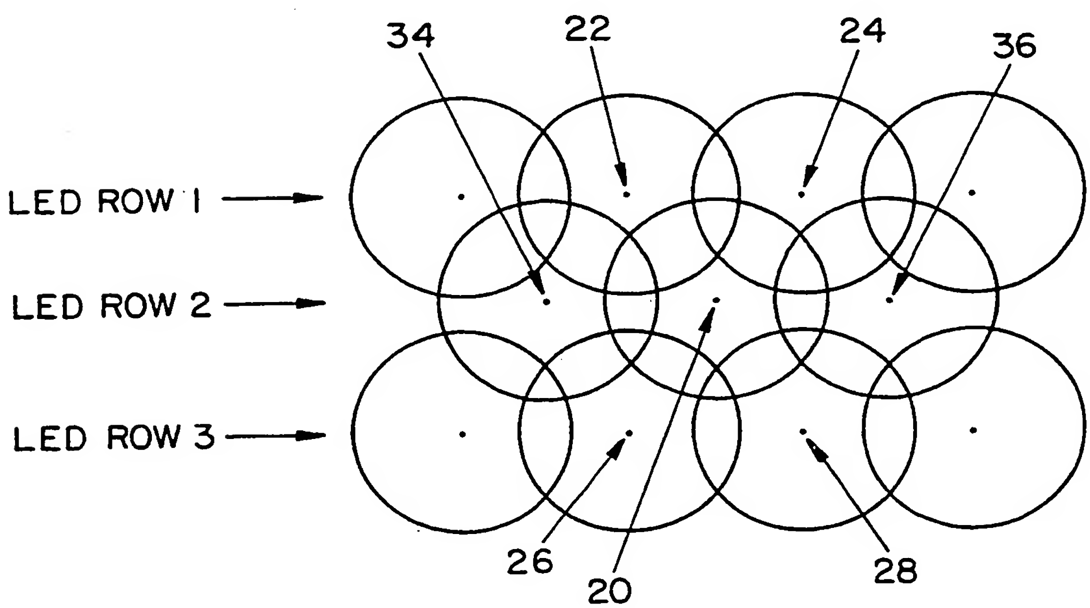

34
22
24
36
LED ROW 1
LED ROW 2
LED ROW 3
26
20
28

Fig. 2

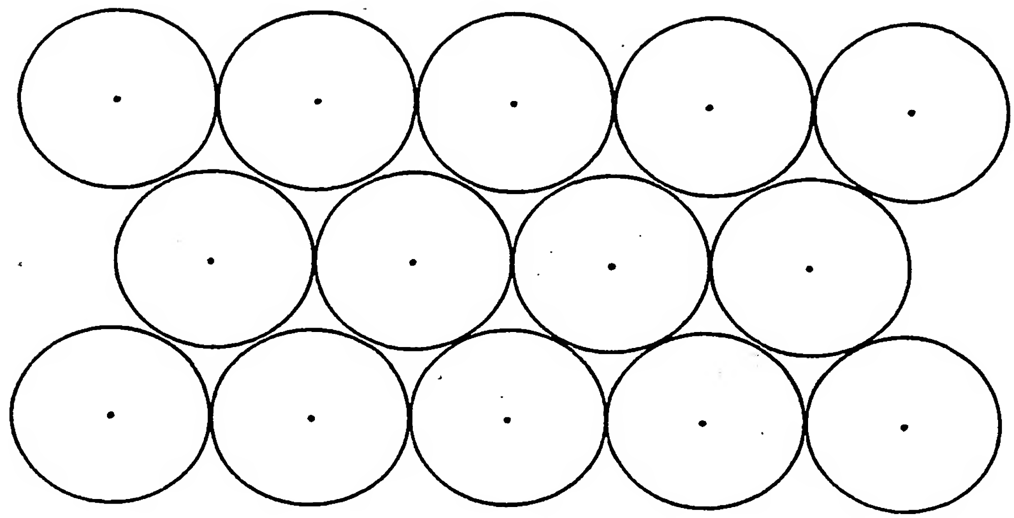


Fig. 3

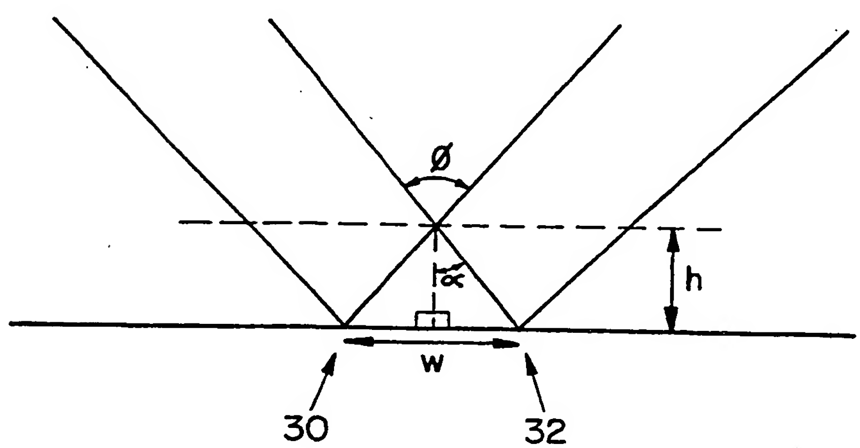


Fig. 4

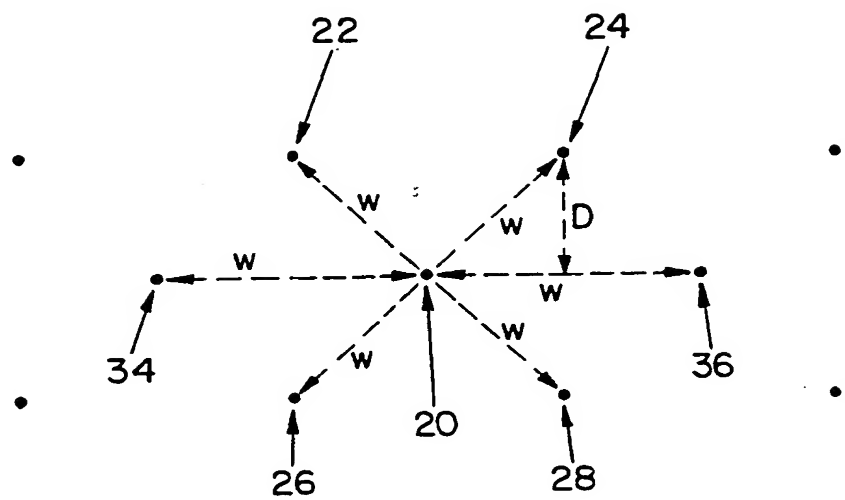


Fig. 5

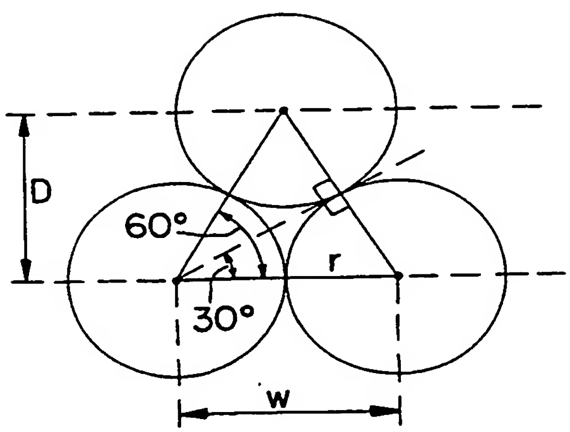


Fig. 6A

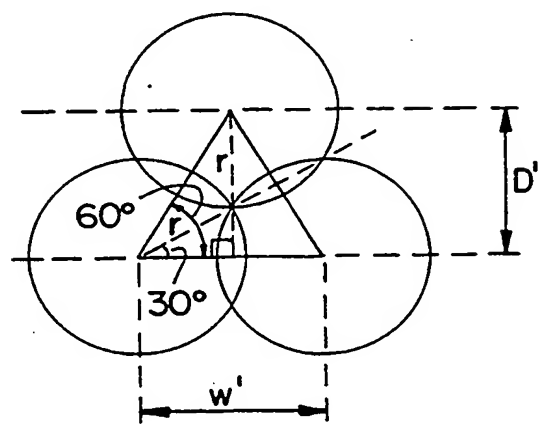


Fig. 6B

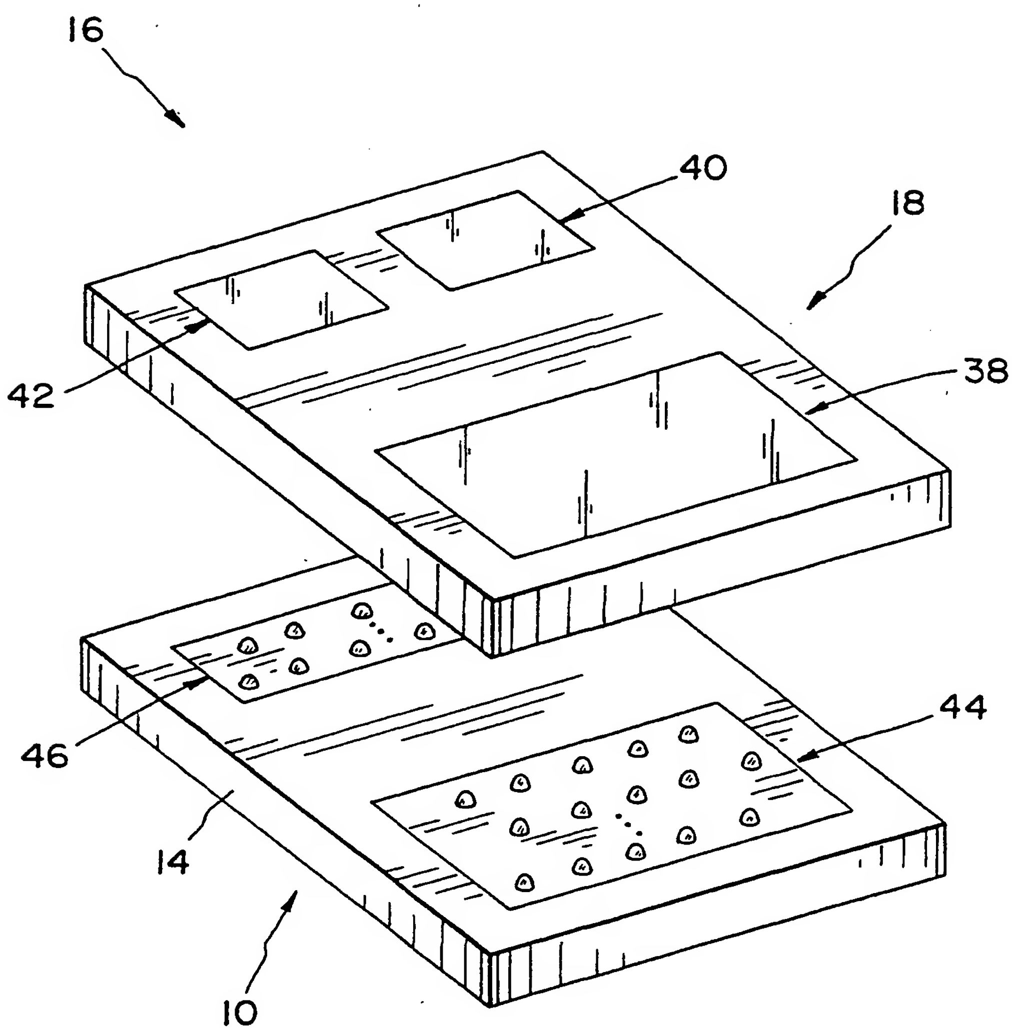
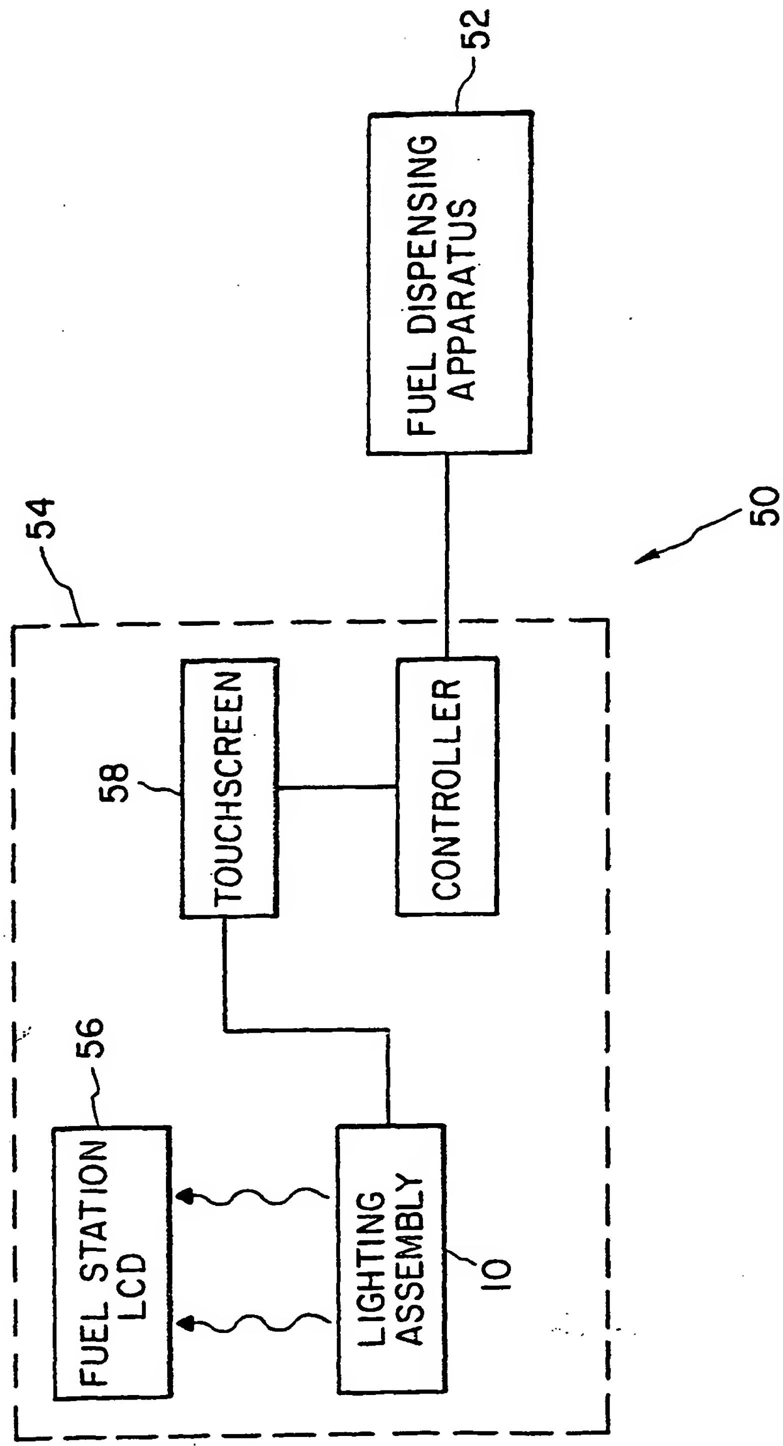


Fig. 7



FUEL DISPENSING APPARATUS
52
50
54
TOUCHSCREEN
58
CONTROLLER
FUEL STATION LCD
56
LIGHTING ASSEMBLY
10

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/02462

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : F21S2/00
US CL : 362/252
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : Please See Continuation Sheet

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- y	US 4,593,485 A (THILLAYS) 10 June 1986 (10.06.1986), Figure 1 and columns 4-6	1-10 ------ 1-10
X --- Y	US 4,975,814 A (SCHAIRER) 04 December 1990 (04.12.1990), Figure 3, columns 2 and 3	1-10 ------ 1-10
X --- Y	US 5,515,253 A (SJOBOM) 07 May 1996 (07.05.1996), Figures 3, 5 and 6, colums 2 and 3	1-10 ------ 1-10
Y	US 5,765,940 A (LEVY et al.) 16 June 1998 (16.06.1998), Figure 1, column 5, lines 22-68	1-10
X --- Y	US 5,819,454 A (ROSENITSCH) 13 October 1998 (13.10.1998), column 2, lines 13-54	1-10 ------ 1-10
X --- Y	US 5,820,246 A (HELSTERN) 13 October 1998 (13.10.1998), columns 2 and 3	1-10 ------ 1-10

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 March 2000 (24.03.2000)	22 JUN 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer Sandra O'Shea Telephone No. 703-308-0956

Form PCT/ISA/210 (second sheet) (July 1998)

Continuation of B. FIELDS SEARCHED Item 1: 362/252,31,551,559,558,800,561
40/448,452

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